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Optics Damage Inspection for Large Laser Systems

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ABSTRACT

The NIF laser system will have 192 high power laser beams, each with over 40 large optics. At full output, the laser power in each beam will be sufficient to highly stress the large optics in the beamline. Damage to the optical surfaces is expected, and damage sites are expected too grow with repeated exposures. Some of the large optics are under vacuum and failure to replace them in a timely manner could result in an implosion causing major damage to the system. Also, laser hot spots caused by diffraction modulation from damage sites can cause damage to propagate to other optical components down the beamline. The majority of the large optics will be inaccessible for convenient manual inspections to determine the extent of damage. Therefore, a system for automated optics inspection is required on NIF to ascertain when the optics need to be replaced.

In this paper we describe two options for an optics damage inspection system. Due to system cost constraints, only two options were considered viable. Concepts with specialized sensors dedicated to each optic or to each beamline were considered too expensive. Inspections must either employ the same NIF sensors planned for laser diagnostics, or must employ sensor multiplexing so that a few sensors can service many beams. In this report the expected performance for sensors employing these two options are evaluated by experiment and analysis.

The first option would employ laser output diagnostic sensors. Illumination would be provided by the alignment laser. The added cost would be low because the diagnostic sensors and alignment lasers are already included in the baseline design. However, resolution is limited with this option because the pick-off mirror to the diagnostic sensor is limited in size to keep it from interfering with other beams (input beam, alignment beams, diagnostics beams, and reflected beams to beam dumps) that pass through the transport spatial filter.

The second approach would employ a few multiplexed sensor/illuminator packages. A robot is planned in NIF to pick off a beam from each laser bay for detailed diagnostics. This same robot would be used to put a sensor/illuminator into place (or to pick off/insert a beam) for damage diagnostics. A second sensor/illuminator package would be required at the target chamber. Therefore, three sensor packages would suffice for the entire NIF, one for each of two laser bays and one in the target chamber. This approach was selected as the NIF baseline concept.

A scaled-down NIF beamline was used to investigate the performance of optics damage sensors using these two approaches. The beamline is scaled one-to-one with NIF in cone angles within the spatial filters, but is one-tenth scale in collimated beam size and optical system length. By taking into account these scale factors in selecting the size of the pick-off mirror and the magnification of the sensor telescope, we achieved the same optical system and TV camera resolution relative to a damage site as would be expected on NIF. Used blast shields from the NOVA laser were used to place known actual damage sites at various points along the beamline to evaluate sensor performance.

In addition to resolution, the simulated beamline was used to evaluate several other issues and options associated with the inspection task. These include darkfield methods, depth of field for distinguishing between damage in nearby optics, methods to distinguish between damage sites at mutual relay planes, and the effect of random and kinoform phase plates on imaging final optics assembly damage.

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